Backup 10 crossings to establish history. Look at 20 + 10 crossings. For each crossing:

$\langle n \rangle$ = 18 minbias events, pick n out of Gaussian

dy = 0.087 "square" tower in $d\eta$ x $d\varphi$

P = prob to have minbias particle in tower
 ~ ρ n dy (dy/2π), ρ = 8 particles/unit y.

For n = 18 and dy=0.0875, P = 0.17.

If particle is in tower it deposits Et ~ 0.75 GeV

Shaping time of RC-CR preamp = τ. Energy deposited in time as $(t/\tau)\exp(-t/\tau)$.

Et = 5 GeV signal studied. Begins in crossing 12.
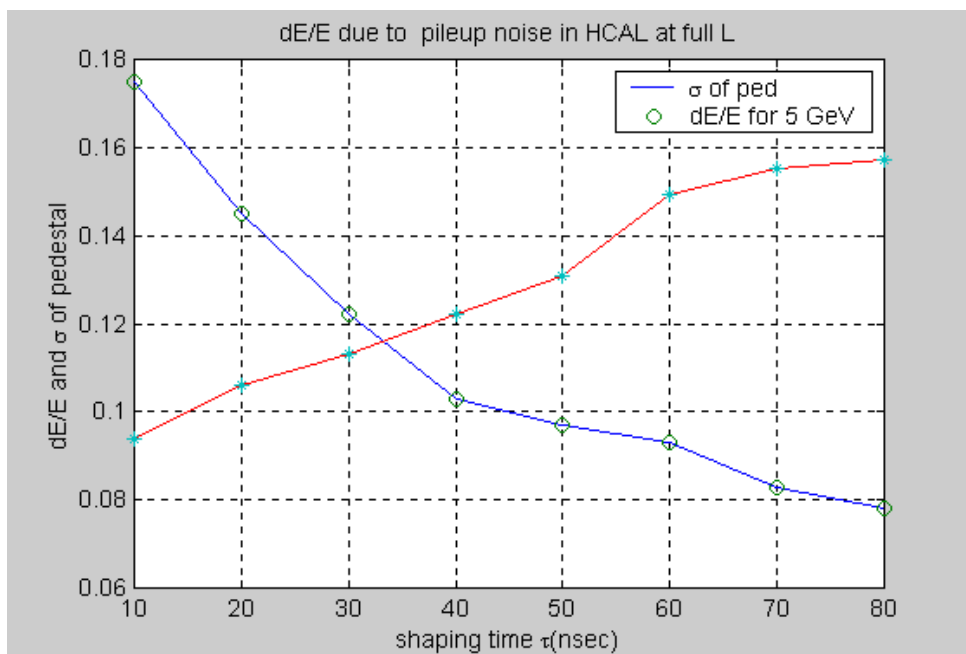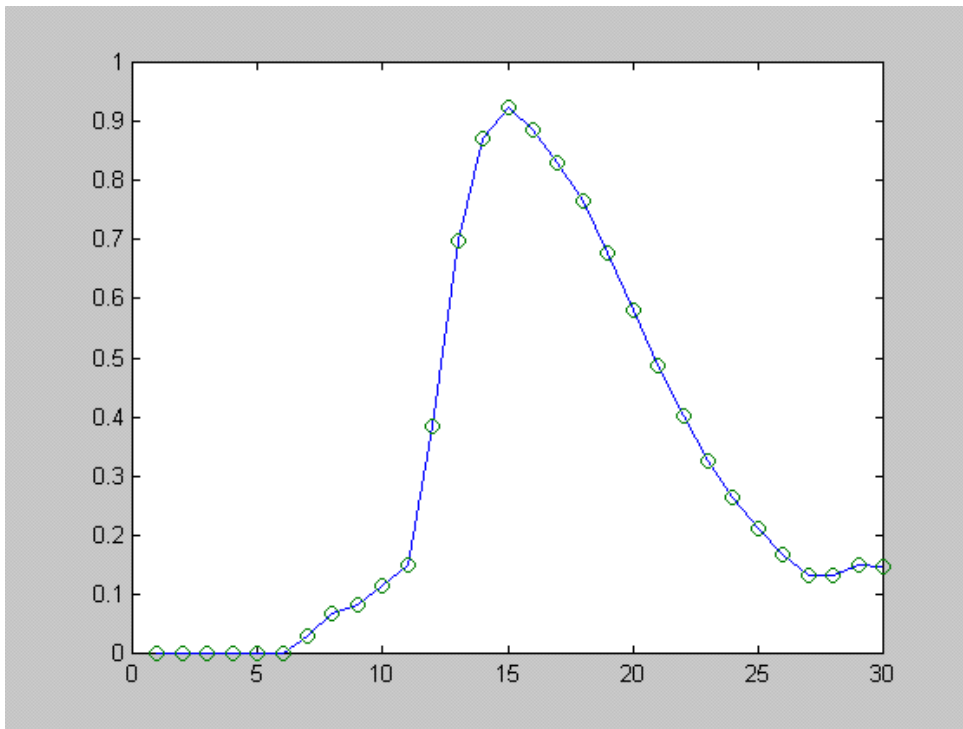
Pileup ~ Pedestal Noise, independent of Et

Use 2 crossings (10 + 11) to estimate pedestal

Ped is independent of shaping time. It is ~ P * Et = 0.75 GeV or 128 MeV.

Use ~ 3τ/25 nsec crossings, ped subtracted, to estimate Et. Rms of ped is ~ ped/sqrt(# crossings used)

Tau = 10, 40 , 80 nsec uses 2, 5, 10 crossings to estimate energy.

dE/E due to pileup noise in HCAL at full L
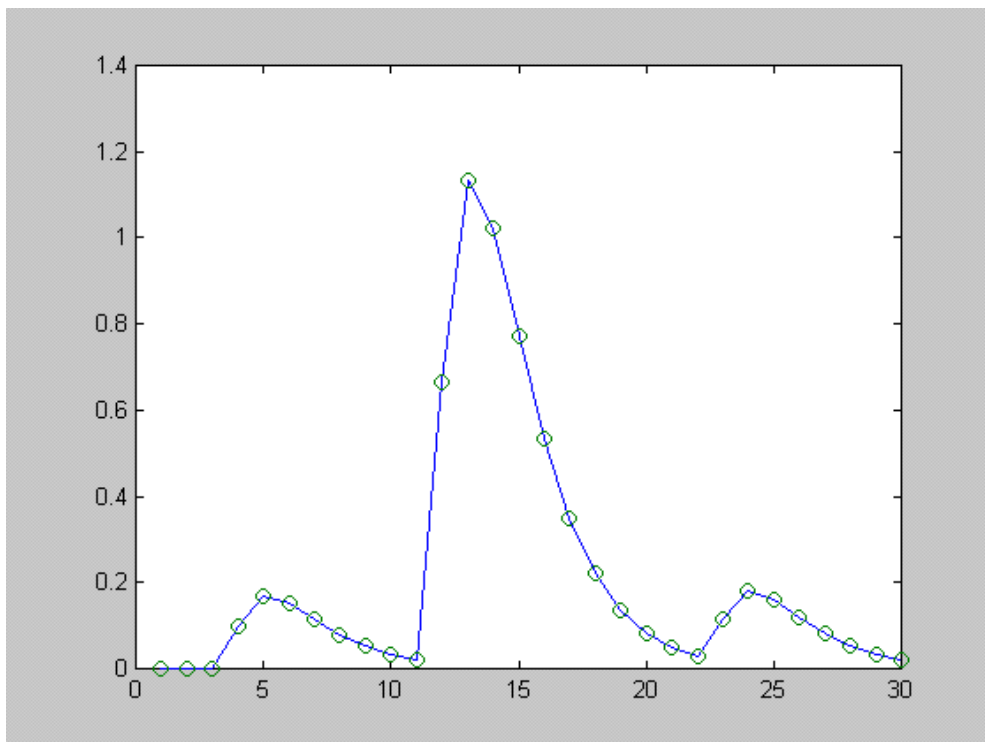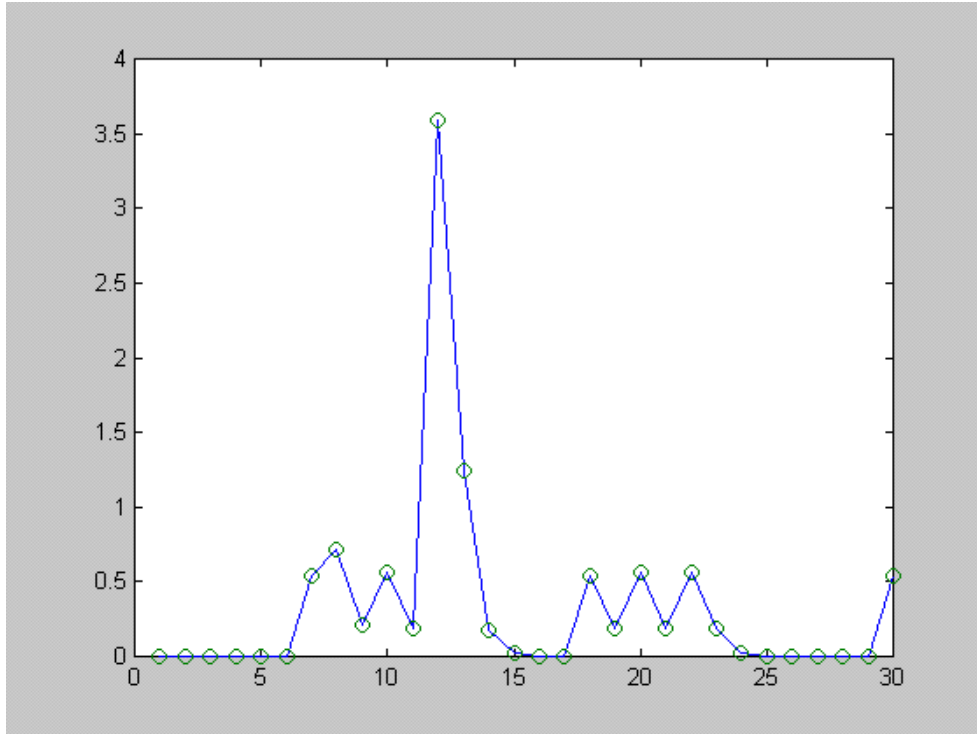
The energy error due to pileup noise is ~ (# crossings used) * rms ped. For shaping times from 10 to 80 nsec that error estimate ranges from 350 to 780 MeV while dE ranges from 470 to 786 MeV.

The HCAL energy response has a 100% stochastic coefficient, a 5% constant term and at least 3 noise terms – front end series, front end parallel and pileup. $dE/E \sim 1.0/\sqrt{E} + 0.05 + 2(GeV*nsec)/[E*\tau] + (parallel) + 0.24\ GeV*[\tau^{1/4}]/E$

Series noise is ~ 2000 e for 20 nsec shaping time. For 10 pe/GeV this is 100 MeV. For Et = 5 GeV the front end series noise is 2%, scaling as $1/\tau$.

The pileup noise varies slowly with τ. The pedestal is ~ independent of τ. However the rms of the pedestal decreases with τ, as seen in the plots for τ = 10, 40, 80 nsec shown above. Thus, pileup noise varies quite slowly with shaping time, roughly as the ¼ power, and therefore the optimal choice of shaping time may be driven by front end noise issues. n.b. the calorimeter constant term is 5% and the stochastic coefficient is 100% which sets a lower limit on the physical energy resolution.

HCAL Energy Resolution Components, 40 nsec Shaping Time